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Grasses and Legumes: Production and Management in South Dakota

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BULLETIN 427 MAY 1953

Grasses and Legumes

PRODUCTION AND MANAGEMENT FOR SOUTH DAKOTA

AGRONOMY DEPARTMENT
Agricultural Experiment Station
SOUTH DAKOTA STATE COLLEGE

Grasses and Legumes
Production and Management in South Dakota

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Grasses and Legumes
Production and Management in South Dakota

By W. W. Worzella, L. O. Fine, J. G. Ross, M. W. Adams, L. F. Puhr, P. L. Carson, and B. L. Brage[1]

Introduction

Forage crops rank far ahead of any other crop in importance in South Dakota. At present, more than 28,400,000 acres, twice the acreage of all other crops combined, are in grasses and legumes (Fig. 1). These furnish a major portion of feed for our grazing animals.

Since more and more emphasis is being placed on grassland farming, considerable acreages of previously cropped land are being seeded back to forage crops. In recent years the state agricultural experiment stations and the United States Department of Agriculture have introduced and developed species of grasses and legumes which are superior to our native types for seed, hay and grazing purposes. A few of these are crested wheatgrass, Ree wheatgrass, and Ladak, Cossack and Ranger alfalfa.

Shift in Acreage Necessary

There are approximately 43 million acres in South Dakota from which agricultural revenue is obtained. At present, about 14.6 million acres are in row and small grain crops (Fig. 1); 1.2 million acres in tame grasses and legumes; and 27.2 million acres in native grasses.

In order to form a more stable agriculture, according to the best sources of information now available, the amount of acreage in cropland and tame grasses should be shifted to 19.5 million acres, and to about 23.7 million acres in native grass. Since about 13.6 million acres would be in small grain and row crops, that would leave 5.9 million acres in tame grasses and legumes. Total acreage of tame and native grasses and legumes combined, would be about 29.6 million acres.

More Forage Can Be Used

The "back to grass" movement may cause concern in some quarters that too much grass may be produced. More grass, however, can be used without an excessive increase in the numbers of livestock, since it can be substituted for more concentrated feeds. Grass and legume hay can be readily stored in stacks and used when most needed. The ranchers and farmers who were fortunate enough to store an ample carryover of hay withstood the drought years of the thirties with least hardship. Production of more forage crops of higher feeding value would insure a more uniform number of livestock, over a series of years, by reducing losses and forced sales of stock because of feed shortages.

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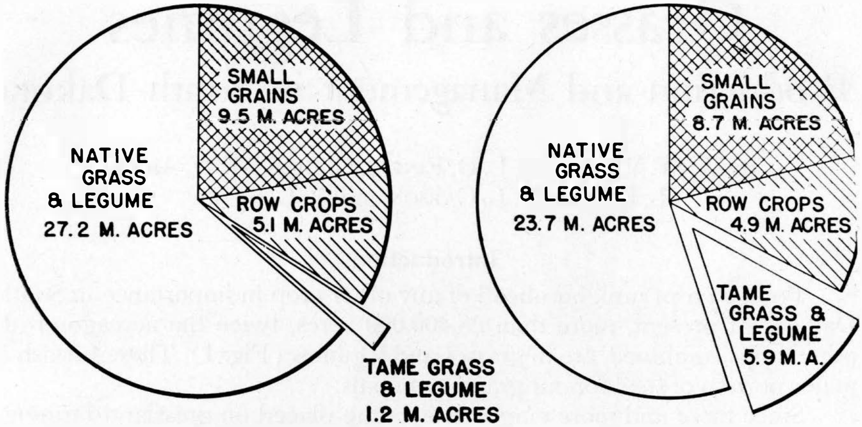


Fig. 1. The use of 43,000,000 acres of productive land in South Dakota

Establishing Stands of Grasses and Legumes

When to Seed

Early spring and early fall are suitable periods for seeding grasses and legumes. Selection of time to seed depends mostly on moisture conditions. In the eastern part of the state, spring seeding usually results in good emergence and survival. If sufficient moisture is present, early fall planting, from the 15th of August to the first of September will give good stands of grass, but is hazardous for legumes. In the central and western parts of the state other factors, such as danger of wind erosion and size of grasshopper populations, are of major importance in selecting the best date of seeding. These factors determine whether early spring seeding, early fall, or late fall (just before freeze-up) may be best.

When irrigation is practised, it is best to seed grasses and legumes very early in the spring when the temperatures are lower and soil moisture is adequate. After the seedlings are established, an early irrigation will give them an additional advantage over the warm season weeds which come up later in the spring. It has been found difficult to start a new seeding of grasses or legumes by flood irrigation because crusting of the soil occurs. Irrigation by sprinkling at repeated intervals to prevent crusting until the seedlings have emerged has given good results. With sprinkler irrigation, seedings can be delayed until early summer, when there would still be adequate soil moisture, and the killing of two or three crops of weeds could be accomplished.

Seed Treatment

To control harmful disease organisms on grass seed, a treatment with Arasan or Spergon at the rate of 8 ounces per 100 pounds of seed is

recommended.[2] Inoculation of legume seed with nitrogen-fixing bacteria is always recommended. This is to assure (1) that nodulation may occur early in the life of the plant, (2) that all plants will have nitrogen fixing bacteria available and, (3) that the most efficient strains of nitrogen fixing bacteria are present. In order to prevent killing of all nitrogen fixing bacteria by seed treatment, apply Arasan or Spergon on the seed about a week before seeding. At the time of seeding, inoculate just enough of the treated seed to fill the drill box for immediate planting.

Seedbed Preparation

A firm seedbed is of prime importance. Stubble ground which has been disced and harrowed provides a firm soil surface, and assures a close contact between the seed and soil as well as protection from soil blowing. The success of establishing stands is assured in most cases if there is no competition from weeds. It is, therefore, desirable to seed in soil as free from weeds as possible. Corn stubble ground quite often makes a good seedbed. Plowed land is not suitable unless well packed before seeding. In the western part of the state, seeding crested wheatgrass on unprepared stubble or "go-back" land in the fall has proved satisfactory.

Depth of Planting

Shallow seeding is essential for good stands. In most cases, seed should not be planted deeper than one-fourth to one-half inch. Seeding in sandy soil, however, may be successful at slightly over an inch in depth. Drill seeding is superior to broadcasting, since a uniform shallow depth may be obtained. A press

[2]C. M. Nagel, "Liquid Seed Treatment Reduces Hazard," Reprinted from *South Dakota Farm and Home Research*, Winter 1949-50, Vol. I, No. 2, pp. 25-28.

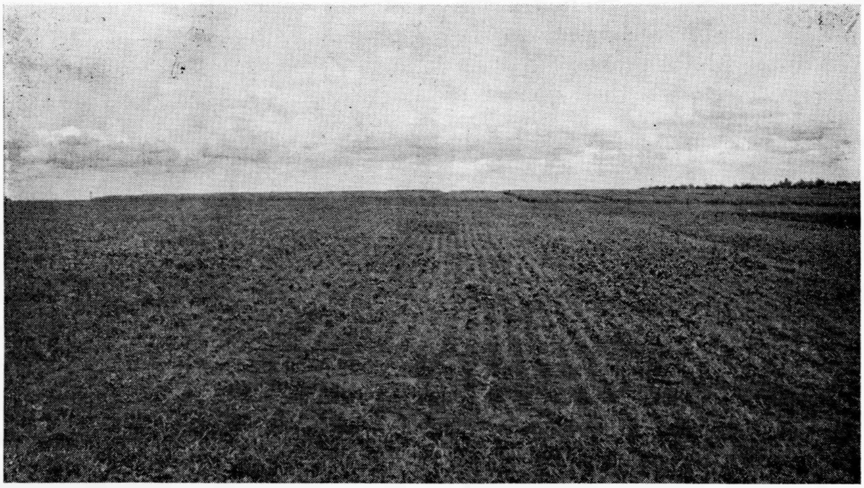


Fig. 2. Stand of bromegrass eight weeks after seeding with cultipacker grass seeder

drill is preferable as the soil is packed directly over the seeds. All pressure should be removed from the discs of the drill by releasing the spring tensions. Cultipacking after seeding will give further assurance of a stand, provided wind erosion is not a problem, or provided erosion is controlled by a trash cover. The use of a grass seed attachment on a cultipacker has given excellent results (Fig. 2).

Starter Fertilizer

The use of a starter fertilizer, such as 16-20-0 or 11-48-0, at the rate of 50 to 100 pounds to the acre, placed at a slightly greater depth than that of the seed, provides nutrients for the young seedlings immediately after they germinate. The fertilizer may be applied with the fertilizer attachments on a grain drill, or spread on top and worked in by discing or dragging.

Companion Crop

Where moisture is limited, a companion crop may compete so successfully with the grass seedlings as to reduce severely their chance of survival. Flax is the safest companion crop to use. Other small grains, because of their vigorous growth, often give too much competition, unless their rate of seeding is cut in half by plugging every other drill hole.

When weeds are very plentiful, better stands generally result if the grass and legume are seeded with a companion crop. If seeded without a companion crop, weed growth is generally heavy after fall and early spring seedings. Weeds should then be clipped, preferably during cool weather, at a height of about 6 to 8 inches to prevent injury to the seedlings. New seedings should not be cut for hay or pastured the first season. In the case of early fall seedings, however, a cutting of hay often can be taken the following summer.

Broad-leaved weeds in a new stand of grass may be controlled by spraying with 2,4-D after the grass seedlings are well established. If alfalfa or sweet clover are present, spraying with 2,4-D is not recommended because the legumes may be injured.

Varieties and Strains

Growing adapted varieties insures more stable production. Using unadapted varieties often invites disaster and causes wide fluctuation of feed supplies. Some varieties are more winter-hardy or possess greater drought resistance, while others winterkill and are drought susceptible. Because of these varying characteristics, no one variety or species is best for all locations or situations.

Performance of Legume Strains and Varieties

Alfalfa. Alfalfa can be grown throughout South Dakota on nearly all soil types. Because of our extremes in rainfall, temperature and

Table 1. Performance Test of Standard Varieties and Selected Strains of Alfalfa Seeded at Brookings in 1948

	Percent Stand		Fall Dormancy	Yield in Tons per Acre			
				1949	1952		
Variety*	Spring 1949	Fall 1952	Height in Inches Sept. 24, 1949	2 Cuttings	1st Cut	2nd Cut	Total
Ladak	68	65	8	4.49	2.17	1.19	3.36
Williamsburg	66	50	23	3.84	1.89	1.06	2.95
Grimm	88	40	18	4.00	1.66	1.23	2.89
Oklahoma Common	42	20	15	3.55	1.57	1.08	2.65
Narragansett	96	80	8	4.41	2.17	1.02	3.19
Kansas Common	15	15	12	3.52	1.52	1.28	2.80
Atlantic	73	70	10	3.97	2.14	1.19	3.33
Ranger	90	80	8	3.75	1.91	1.14	3.05
Buffalo	50	45	11	3.56	1.92	1.20	3.12
A224†	50	50	10	3.42	2.02	1.13	3.15
A225	72	75	12	3.95	2.33	1.23	3.56
77-C228	84	75	12	4.39	2.15	1.17	3.32
77-C233	60	65	12	4.23	2.20	1.27	3.47
77-C236	72	80	10	4.05	2.41	1.27	3.68

*Varieties not necessarily in order of merit for South Dakota conditions.
†Experimental numbers not named and not available.

growing season, and varied uses made of the crop, no one variety is completely satisfactory in all areas. Ladak, for example, which is eminently suitable for hay production in the central and western part of South Dakota, is not desirable in the southeastern counties where three cuttings are customarily taken. In the eastern portion where bacterial wilt is apt to be prevalent, Ranger will give longer-lived stands, but in central and western South Dakota, Ladak or Cossack will do better.

In choosing a variety, due consideration should be given to varietal performance in relation to expected use and area where grown. The chief characteristics helpful in selecting a variety are: (1) stand survival, which is a function of winter injury resistance and of disease (wilt) resistance; (2) recovery rate after cutting, which is related to aftermath dormancy; (3) distribution of yield between first and second cutting; and (4) total yield of forage or seed for the season. These features are emphasized in the performance trials reported in Tables 1 and 2.

Other attributes which may also be of importance in special circumstances are (1) type of crown development, (2) leaf color, (3) foliage disease resistance, (4) root-top ratio, (5) ability to grow with grass, etc. For the most part, these have not been determined for the strains reported here.

Several aspects of strain performance are brought out in Table 1. First, strains from areas with milder winter conditions than we have in South Dakota, such as Williamsburg and Oklahoma Common, invariably suffer stand depletion at an

early stage. Low yields in succeeding seasons are the consequences. Secondly, the degree of fall dormancy as indicated by height of plants in the fall of the year is generally related to the ability of strains to "harden off" and go into the winter in a hardy condition. Data are shown only for '49 and '52 to point out more clearly these differences.

Among the older strains, Ladak from the beginning was at, or near, the top in yield. Narragansett and Atlantic have also performed well. Several of the advanced strains have performed as well or better than Ladak (77-C228, 77-C236); this is more evident in recent years and reflects the greater winter resistance and disease resistance (to bacterial wilt) of the newer strains.

Under irrigation the foliage and systemic diseases have been found to be more intensified, and it consequently is expected that disease resistant strains would show up as definitely superior under such growing conditions.

In Table 2, where some of the newer strains are compared with a few of the standard types in a test seeded in 1950, it will be seen that Ladak is still one of the two or three top-yielding varieties. Some of the newer synthetic strains appear very promising. Standard types, such as South Dakota Common, Ranger and Atlantic, are inferior in yield. Other new varieties obviously are outside their area of adaptation (Nomad, Sevelra, DuPuits, Talent, Williamsburg) though they may possess specific attributes of value under certain conditions.

Red clover. Red clover has been grown on 10,000 to 36,000 acres annually (alone or with Timothy) in

Table 2. Performance of Some New Strains of Alfalfa Compared with Standard Varieties in a Test Established at Brookings in 1950

	Percent	Recovery	Yield of Hay in Tons per Acre			
	Stand	Height in Inches	1951	1952		
Strain*	1952	July 19, 1952	August	1st Cut	2nd Cut	Total
Ladak	88	7	0.97	2.91	0.95	3.86
Sevelra	85	8	0.77	2.25	1.10	3.35
Nomad	70	5	0.79	2.12	.80	2.92
Wisconsin Syn C	95	10	0.85	2.58	1.18	3.76
South Dakota Common	95	9	0.74	2.50	1.19	3.69
Ranger	98	10	0.75	2.36	1.03	3.39
Atlantic	80	8	0.78	2.40	1.14	3.54
DuPuits	92	12	0.70	2.27	1.21	3.48
Talent	90	10	0.63	2.00	1.06	3.06
Williamsburg	90	11	0.72	2.26	1.13	3.39
Narragansett	95	12	0.84	2.52	1.19	3.71
A226	90	12	0.78	2.49	1.26	3.75
A228	95	9	0.94	2.86	1.09	3.95
A227	98	10	0.90	2.58	1.16	3.64
A229	90	7	0.91	2.67	1.14	3.81
Average	----	----	**0.80**	**2.45**	**1.11**	**3.56**

*Not necessarily in order of merit for South Dakota conditions.

Table 3. Yield Performance of Red Clover Strains in Two Tests at Brookings in 1950-51

Strain*	Yield of Hay in Tons Per Acre 1951 1st Cut	1952 1st Cut	1952 2nd Cut	1952 Total
Emerson	1.84	2.24	1.33	3.57
Kenland	2.07	2.32	1.18	3.50
Dollard	2.29	2.16	1.11	3.27
Libel	2.04	1.89	1.21	3.10
Mammoth	----	2.77	0.48	3.25
Rahn	1.79	2.06	1.33	3.39
Van Fossen	1.99	2.42	1.09	3.51
Wegener	1.82	2.14	1.03	3.17
Ottawa	1.89	2.43	1.09	3.52
Midland	2.10	2.26	1.02	3.28
Pennscott	1.67	2.33	0.85	3.18
Average	**1.95**	**2.27**	**1..07**	**3.34**

*Not necessarily in order of merit for South Dakota conditions.

South Dakota during the past decade. Strains collected throughout the Corn Belt and eastern Canada, when tested in eastern South Dakota, show relatively small differences in yield (Table 3), and nearly always yield less than alfalfa grown under comparable conditions.

In a year when the disease known as Northern Anthracnose is serious, the Dollard strain, which is somewhat resistant to the disease, has a definite superiority. Generally, however, locally grown seed known to have been raised in the vicinity for several years, is as good or better than any of the tested strains.

Birdsfoot trefoil. This legume has not been generally grown in South Dakota because it is not a heavy producer of hay; it requires particular care in establishing, and it has

Table 4. Birdsfoot Trefoil Variety Test, Brookings, 1951-52

Strains*	Percent Stand Nov. 1951	Percent Stand May 1952	Vigor† Nov. 1951	Vigor† May 1952	Percent Flower Production	Recovery in Inches After Cutting July 18	Recovery in Inches After Cutting Aug 14	Yield of Hay‡ Tons/Acre July 7, 1952
Cascade	82	78	2.3	1.3	22	4.0	9.7	1.90
Granger	82	75	2.3	1.0	27	3.7	9.3	1.90
Viking	78	73	2.7	1.7	10	3.0	9.0	2.01
P.I.188101	62	73	4.1	1.3	12	4.0	9.0	1.96
P.I.188867	45	60	6.0	1.7	27	3.0	9.7	1.64
Empire	82	73	2.3	2.7	2	1.0	4.7	2.66
Mandan 1116	70	75	3.5	2.0	27	1.0	4.7	2.36
Oregon narrowleaf	82	42	2.3	3.0	20	0.6	1.7	1.35
New York narrowleaf	85	63	7.3	7.3	67	0.5	2.0	1.24
Average	----	----	----	----	----	----	----	**1.89**

*Not necessarily in order of merit for South Dakota conditions.
†Where 1 is excellent and 10 is poor.
‡One cutting taken at one-half bloom stage.

had an unreliable record with respect to cold and drought resistance in this area. With the advent of newer varieties, some of these shortcomings may be overcome.

In Table 4 are reported the data obtained from birdsfoot trefoil trials. These strains can be grouped according to three types: (1) the Empire type, giving a high first cutting but limited aftermath growth; (2) the narrowleaf type, definitely inferior in yield and aftermath; and (3) the European type in which yield is intermediate in the first cutting but aftermath growth and flowering are fair to good, and much superior in the two latter respects to the Empire type. A final appraisal of their winter resistance has not yet been made. The data reported here are first harvest year results and are not to be construed as final in the sense that any of these entries are to be recommended widely in this state. Birdsfoot trefoil has been most successful in the eastern Corn Belt of the U. S. and the northeastern states when used as a pasture legume in combination with Kentucky bluegrass.

Sweet clover. Throughout the Corn Belt, farmers have been turning to sweet clover for soil building purposes. A considerable portion of the South Dakota acreage, however, is pastured during a part of the first or second year, and many plantings are used for seed production. A simple evaluation based on hay yield, therefore, may not be entirely adequate for appraising the different strains for these various purposes. Nevertheless, since total plant weight (hay yield) bears some relationship to soil building value and to pasture yield, the data in Table 5 are of value.

None of the named varieties would appear to be much better than Common Yellow for soil im-

Table 5. Performance of Sweet Clover Strains in Two Tests at Brookings, 1950-52

	Percent Stand		Vigor†		Yield
Strains*	Fall	Spring	Fall	Spring	Tons/Acre 1952
Spanish	92	82	3	6	2.29
Williamette	87	80	4.5	6	2.79
Redfield	15	1-2	9	—	(weeds)
Alpha	25	0	7	—	(weeds)
Common White	75	62	5	7	2.24
Common Yellow	90	90	4	1	2.25
Artic	68	68	5	6	1.51
Madrid	92	85	3	5	1.85
Brandon Dwarf	90	75	5	7	2.24
Evergreen	95	82	3	5	2.25
Wis. Int. 1	96	30	1	9	0.50
Wis. Int. 1A	85	15	2	5	
Wis. Int. 2	90	30	3	6	2.07
Wis. A 46	90	85	2	1	3.20
N 1	95	90	2	4	3.22

*Not necessarily in order of merit for South Dakota conditions.
†Where 1 is excellent and 10 is poor.

Table 6. Average Yields of Grasses in Tons per Acre at Cottonwood, Highmore, Eureka and Brookings During the 4-Year Period 1949-52

Species or Variety	When Grown Alone				When Grown with Alfalfa			
	Cotton-wood*	Highmore	Eureka	Brookings	Cotton-wood*	Highmore	Eureka	Brookings
	T./A.	T./A.	T./A.	T./A.	T./A.	T./A.	T./A.	T./A.
Ree wheatgrass	0.52	0.52	0.37	2.37	0.94	0.64	0.94	3.26
Lincoln brome	0.31	0.51	—	2.26	0.71	0.69	—	3.12
Homesteader brome	0.33	0.38	0.33	2.25	0.55	0.52	0.86	3.03
Standard crested	0.33	0.35	0.39	0.67	0.79	0.59	0.77	3.00
Lyons brome	—	0.38	—	2.28	—	0.56	—	3.16
Lancaster brome	—	0.46	—	2.01	—	0.54	—	3.26
Western wheatgrass	0.47	0.28	0.26	—	1.32	0.63	1.04	—
Slender wheatgrass	0.33	0.42	0.28	—	1.25	0.69	1.01	—
Green stipagrass	0.36	—	0.33	—	0.82	—	0.99	—
Russian wild rye	0.23	0.18	0.27	—	0.64	0.70	0.72	—
Blue grama	—	0.10	—	—	—	0.63	—	—
Creeping red fescue	—	0.30	0.23	1.72	—	0.55	0.77	2.86
Kentucky bluegrass	—	0.28	—	1.43	—	0.61	—	2.79

*Yield data were not determined at Cottonwood in 1950.

provement and pasture purposes, though some of the later maturing strains such as Evergreen, Spanish, or Madrid may be preferred for pasture use in order to lengthen the grazing period. For seed production, however, these latter strains, except Madrid, may be later than is desirable because of the growing hazards in South Dakota. Two of the unnamed strains appear to be much superior in stand, vigor in the first fall, and total production the second year. Further testing of such strains is being continued.

Performance of Grass Strains and Varieties

Average yields of hay for various grasses, alone and with alfalfa, are reported in Table 6. It will be noted that the hay yields are greater when the grasses are grown with alfalfa than when grown alone. At all locations, the highest yielding grasses are Ree wheatgrass, bromegrass and crested wheatgrass. In the western areas, crested wheatgrass ranks higher in yield than it does in the east. Ree wheatgrass, however, maintains high yielding ability at all locations. Western wheatgrass performed well at Cottonwood, but has not yielded as well at other locations. Green stipagrass has yielded very well at Eureka and quite well at Cottonwood. Slender wheatgrass and Mandan wild rye have not withstood competition from other grasses. The shortgrass, Blue grama, has a very small measurable yield. Both Creeping red fescue and Kentucky bluegrass have very small yields at Highmore and Brookings. Russian wild rye, because it is primarily a low growing pasture grass, has yielded very little as hay.

In Table 7 the yields of Ree wheatgrass and different varieties of bromegrass are reported for 1951 and 1952. Ree wheatgrass has been the top yielder at both locations.

Table 7. Yields of Hay in Tons per Acre of Grass Varieties at Eureka and Brookings, 1951-52

Variety	Eureka 1952	Brookings 1951	Brookings 1952	Brookings Average
	T./A.	T./A.	T./A.	T./A.
Ree wheatgrass	0.55	4.89	2.58	3.73
Homesteader	0.36	4.10	2.58	3.34
Elsberry	0.40	3.85	2.28	3.06
Achenbach	0.50	3.73	2.42	3.07
Lincoln	0.45	3.96	2.28	3.12
Fischer	0.42	4.29	2.30	3.30
Lyons	0.42	3.57	2.12	2.84
Lancaster	0.47	4.21	2.55	3.38
B. In. 12	0.34	3.89	2.12	3.00
Martin	0.40	3.30	2.50	2.90
Manchar	0.36	3.55	2.72	3.13
Mandan 404	0.38	3.88	2.20	3.04
Canadian	0.35	4.10	2.45	3.27

Only small differences between the yields of the bromegrass strains were found, but Homesteader was near the top in yield at Brookings in 1951 and 1952.

In general, Ree wheatgrass and bromegrass are the most productive grasses in the eastern part of South Dakota. In the central area, Ree wheatgrass, bromegrass or crested wheatgrass are adapted. In the western part of the state, Ree wheatgrass has given the highest yield at Cottonwood. Crested wheatgrass makes growth very early in the spring and late in the fall at the periods when the range grasses are not productive. For this reason it makes a very valuable supplementary pasture.

Why a Mixture of Grass and Legume

For pasture and hay a mixture of grass and legume is best. For seed production, however, a pure stand of one or the other is generally better because of harvesting difficulties encountered with a mixture. Grass-legume mixtures are best for forage for the following reasons:

1. Forage yields of mixtures are always higher than grass alone and quite often more than the legume by itself. This is shown by results obtained at Cottonwood, Highmore, Eureka and Brookings (Tables 6 and 8, Fig. 3).

2. Pasture or hayland will continue in high production if a legume is maintained in the mixture. This is shown in Table 8. In a pure stand of grass, nitrogen is exhausted and

Table 8. Hay Yields in Tons per Acre of Bromegrass Alone, and a Mixture of Bromegrass and Alfalfa at Brookings, 1946-49

Year	Bromegrass	Bromegrass and Alfalfa	Increase of Mixture Over Grass Alone
	T./A.	T./A.	%
1946	2.80	3.78	135
1947	1.69	5.56	329
1948	0.90	3.32	369
1949	0.39	1.88	482
Average	**1.44**	**3.63**	**329**

yields drop. Legumes in mixtures supply nitrogen to the grass and the yields are maintained. Satisfactory yields usually are obtained from bromegrass or the alfalfa-brome mixture the first year after the stand is established. Following the first year, the yields of bromegrass usually decline each succeeding year. As noted in Table 8 the alfalfa-brome mixture produced good yields throughout the 4-year period.

3. In a grass-legume mixture, more nitrogen will be fixed by the legume than if it were a pure stand, because most of the naturally occurring nitrogen is used by the grass and is not available to the legume plant.

4. Grasses in a legume mixture contain a higher percentage of protein than grass grown alone.

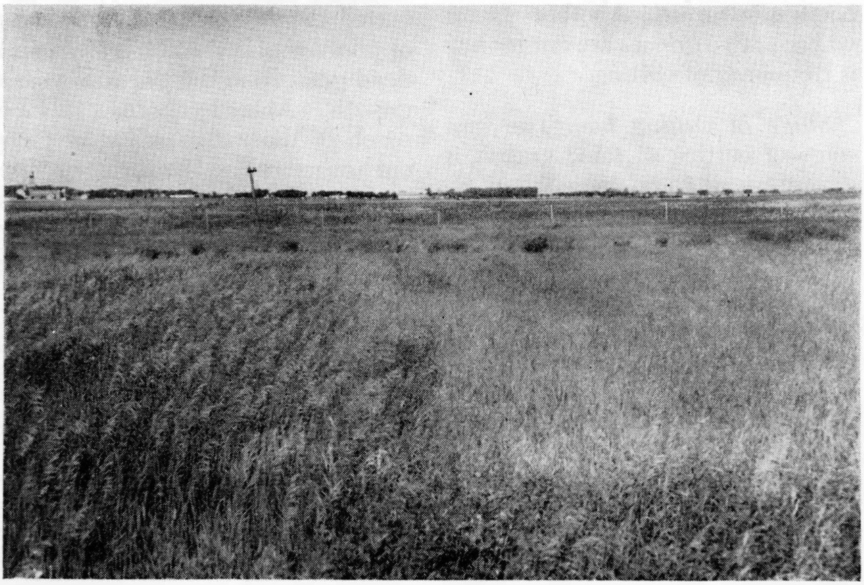
5. The inclusion of grass (50 percent) with a legume reduces somewhat the chance of bloat from legumes.

6. Better erosion control and improved soil structure are effected when grass is included with a legume.

7. Greater control of weeds is given when grass is included with a legume. Grass fills up all vacant areas.

8. The hazards affecting young seedlings of two species will not be the same, so that seeding a mixture may provide more assurance of a stand.

9. A number of species will tend to accommodate themselves to the range of conditions within the field and assure a complete forage cover.



A B

Fig. 3. Grass legume mixture (A) always produces more forage than grass alone (B)

Management for Hay Production

Management practices for maximum hay production are different from those aimed at seed production. Likewise, management for hay production under non-irrigated conditions is somewhat different from that recommended for irrigated conditions. For this reason separate treatment is given the two situations.

Non-Irrigated Hay Production

Best success for hay production in years of average rainfall requires a combination of factors under the control of the farmer. These are (1) use of the adapted species as discussed earlier, (2) cutting at the proper stage of growth, (3) use of fertilizer where stand, soil conditions and the species' productive capacities warrant. Another factor where native grasses are cut for hay is frequency of cutting.

Stage of cutting hay. The best stage of cutting of tame grasses is generally said to be immediately after heading. Later cutting results in lower protein and higher crude fiber content with most species. Because of leaf drop and other factors, cutting at the heading stage usually results in the maximum tonnage yields. With sweet clover, alfalfa and red clover, the recommended cutting stage is the early blossom stage. This is especially important with sweet clover. Red clover may be permitted to go to the full bloom stage without causing deterioration of the forage.

Frequency of cutting of native grasses. Hay yields, largely of western wheatgrass, obtained at Eureka and Cottonwood when cut at various intervals, are reported in Table 9.

The average yield was about the same for plots harvested every year and those cut once every two years. Those cut once in three years, however, produced much less hay on a yearly basis. The hay harvested each year and every other year was of high quality. That from plots harvested once every three years was of poorer quality due to weeds and dead grass from the previous year's growth. Annual weeds replace much of the native grass on plots cut every year. Because of the weeds and greater harvesting costs involved when grass is cut every year, it appears that harvesting every two years is best.

Fertilization. The use of fertilizer, to be profitable, must be tempered with consideration of the stand of the crop, its productive ca-

Table 9. Yields of Native Hay in Tons per Acre According to Frequency of Cutting

	Cottonwood Harvested			Eureka Harvested		
	Each Year	Every 2 Yrs.	Every 3 Yrs.	Each Year	Every 2 Yrs.	Every 3 Yrs.
	T./A.	T./A.	T./A.	T./A.	T./A.	T./A.
Yield at harvest	.38	.65	.77	.59	1.09	1.23
On yearly basis	.38	.33	.26	.59	.55	.41

Table 10. Tons of Grass Hay Produced per Acre When Various Amounts of Nitrogen Were Applied on Non-irrigated Plots

Pounds of Nitrogen/Acre	Bromegrass			Crested Wheat	Native Grass
	Hand County 1945	Brookings County 1950	Brookings County 1951	Lyman County 1951	Haakon County 1952
	T./A.	T./A.	T./A.	T./A.	T./A.
0	0.81	1.20	0.88	0.74	0.52
20	0.98	----	----	0.87	0.37
40	1.62	2.60	1.70	1.22	0.49
60	----	----	2.01	1.38	----
80	------	2.90	2.34	----	0.57

pacity, and the nature of the soil. A further consideration, and one which is the most difficult to evaluate, is that of adequacy of moisture. If stand is adequate and the species has the capacity to produce, soil fertility must be adequate at the time moisture is available in the growing season to obtain maximum yields. In years of subnormal spring rainfall, application of fertilizer may have no result. However, at Highmore an experiment conducted from 1942–1948, inclusive, resulted in an average annual yield increase of 1087 pounds of grass hay per acre with an application of only 10 pounds of nitrogen as ammonium sulfate. Responses of this magnitude may be above the average for central South Dakota (Fig. 4).

Some typical results of experiments with nitrogen fertilizers on grasses are given in Table 10. Rates of actual nitrogen applied are shown. Thus, 20 pounds of nitrogen per acre is supplied by 100 pounds of 20-0-0 or 60 pounds of 33-0-0.

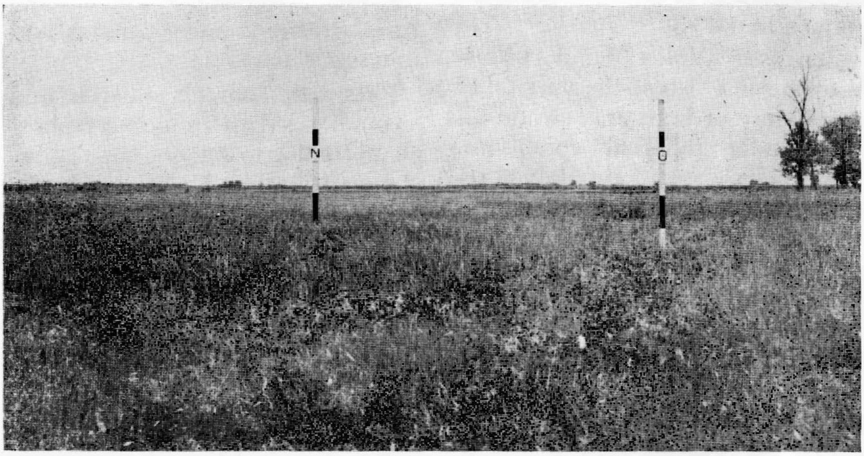


Fig. 4. Showing growth response of bromegrass to nitrogen fertilizer applied as top-dressing in early spring

Table 11. Tons of Alfalfa Hay Produced per Acre When Various Amounts of Phosphate Were Applied on Non-irrigated Plots

Pounds P_2O_5 per Acre	Deuel County 1948	Lake County 1949	Lake County 1950	Brookings County 1951*	Tripp County 1950*	Spink County 1951
	T./A.	T./A.	T./A.	T./A.	T./A.	T./A.
0	1.62	2.99	2.47	1.17	1.40	2.54
20	------	------	------	------	1.79	2.67
40	1.93	3.43	2.90	------	2.12	2.52
80	2.47	3.74	2.81	2.77	------	------

*One cutting only.

Depending somewhat on stand, moisture conditions and kind of grass, the application of nitrogen fertilizer at the rate of 40 pounds of nitrogen per acre will usually effect a yield increase of from 500 to 1600 pounds of hay per acre. In general, bromegrass, Ree wheatgrass and tall wheatgrass will give greater tonnage responses than will crested wheatgrass and native grasses.

The results of several experiments with phosphates on alfalfa are presented in Table 11 and Fig. 5. Rates of actual P_2O_5 are shown. Thus 20 pounds of P_2O_5 would be supplied by 100 pounds of 0-20-0 or about 47 pounds of 0-43-0.

Results in Tables 10 and 11 illustrate to some extent the variability in response of both grasses and alfalfa under different conditions. Nevertheless, very profitable responses generally are obtained from the application of nitrogen to good stands of grasses, or of phosphate to good, vigorous alfalfa stands. Most soils in the eastern part of South Dakota have been depleted of available phosphate to the point where application of 40 pounds of P_2O_5 can be expected to result in 700 to 1000 pounds of additional alfalfa hay being produced. However, application of phosphate fertilizer to non-irrigated alfalfa on the shale-derived soils of western South Dakota has not been proved profitable. These soils are higher in total phosphorus content than most eastern South Dakota soils.

Fertilizers may be applied on established stands of either grasses or legumes by broadcasting on the surface early in the spring or in the fall of the year before snow covers the ground.

Nitrogen sources available and recommended are ammonium nitrate (33-0-0), ammonium sulfate (20-0-0), urea (46-0-0) and in some areas, urea-ammonia solutions and anhydrous ammonia.

Phosphate sources available and recommended are treble superphosphate (0-43-0 to 0-48-0), superphosphate (0-20-0) and in the southeastern and eastern counties, calcium metaphosphate (0-63-0).

Irrigated Hay Production

Since the purpose of irrigation is to prevent lack of water from limiting crop growth, water must be available at the times needed by the crop and in sufficient quantity. Some crops have very definite peak periods in water use. Other crops

have definite stages of growth in which adequate moisture is more important than in other stages. The forage crops do not have characteristic peak periods of use, but do make better growth and recovery if adequate water is available at the beginning of a growing season or immediately after a hay crop is removed.

Experiments at the Redfield Irrigation Development[3] farm have shown that at least 4 inches of water are required for each ton of alfalfa hay produced per acre. Experiments in other states have shown that grasses require about 10 to 20 percent more water than alfalfa, per ton of hay produced. Thus, in irrigating hay crops, it is of utmost importance to apply enough water and to apply it preceding or immediately following the removal of the previous hay crop, or at any time a moisture deficiency arises during the growth period. Severe moisture stress in alfalfa can usually be detected by the bluish-green color which characteristically develops in dry weather. Irrigation should be accomplished before the stress

[3]Conducted cooperatively by the South Dakota Agricultural Experiment Station and the Bureau of Reclamation, USDI.

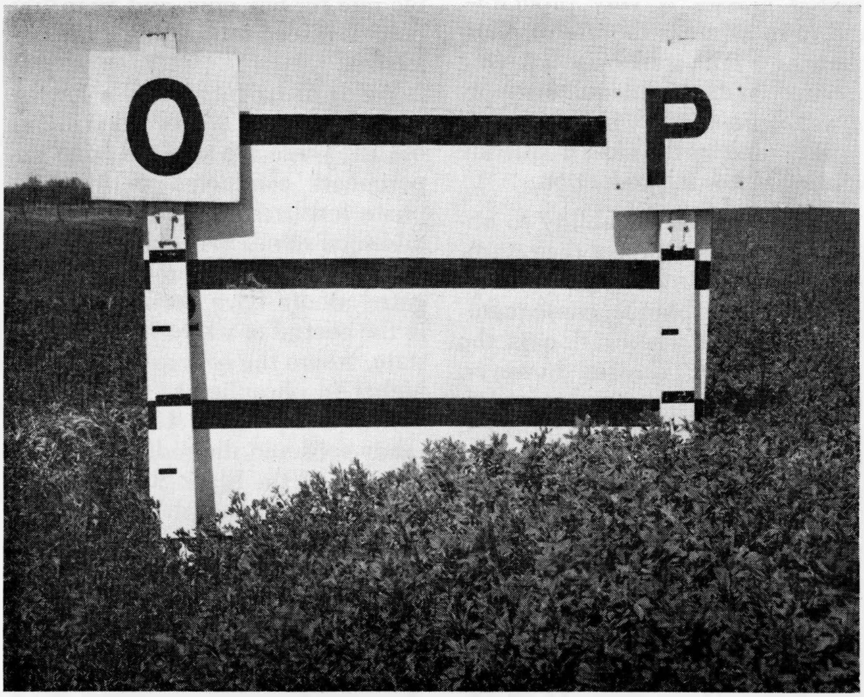


Fig. 5. Response of alfalfa to early spring top-dressing of phosphate fertilizer. Application of 200 pounds of treble superphosphate per acre resulted in a yield increase in the first cutting of 1.6 tons of hay over the untreated area at the left

Table 12. Tons of Grass Hay per Acre When Various Amounts of Nitrogen Fertilizer Were Applied Under Irrigation

Pounds of Nitrogen per Acre	Bromegrass Beadle County 1951*	Bromegrass Beadle County 1952	Bromegrass Spink County 1952*	Crested Beadle County 1951*	Crested Beadle County 1952	Ree Beadle County 1951*	Ree Beadle County 1952	Red Fescue Beadle County 1952	Tall Wheat Beadle County 1951*	Tall Wheat Beadle County 1952
	T./A.	T./A.	T./A.	T./A.	T./A.	T. A.	T./A.	T./A.	T./A.	T./A.
0	0.57	0.82	0.42	0.34	0.97	0.55	1.07	0.75	0.33	1.65
40	1.34	1.29	1.04	0.82	1.41	1.29	1.85	1.71	0.52	1.72
80	1.87	1.92	1.46	1.17	1.54	1.51	2.07	2.22	0.91	2.45
160	1.99	3.49	2.04	1.44	1.66	1.83	2.70	3.46	1.07	3.36

*One cutting only.

reaches this severe stage to keep production at a maximum. Judgment and experience are valuable assets in this respect.

Fertilization. In all parts of South Dakota, nitrogen fertilization of irrigated grasses is very profitable, and in most areas the use of phosphate on alfalfa is likewise a paying practice. With an adequate supply of water provided by irrigation, soil fertility remains the most frequently limiting factor in production.

Legumes have the ability to obtain the major portion of their nitrogen from the air if adequately supplied with phosphorus; consequently, phosphorus fertilization is the major problem. Grasses, however, having lower phosphorus requirements than alfalfa and no nitrogen-fixing bacteria, are usually limited in growth by low soil nitrogen. Some of the typical results obtained in recent experiments with nitrogen on grasses are presented in Table 12.

The results of nitrogen applications on irrigated grasses have been quite striking. As indicated in Table 12, the yields of hay have often been doubled by the use of 40 pounds of nitrogen (120 pounds of 33-0-0) per acre. The rate of nitrogen recommended depends upon the kind of grass being grown and whether or not seed production is desired. It appears that about 40 to 60 pounds of nitrogen per acre is a very profitable rate for hay only, and 80 to 100 pounds if seed production is the objective.

Yields of irrigated alfalfa hay at several locations are recorded in Table 13. These are selected from experiments conducted with phosphate fertilizers top-dressed on established stands in all cases.

Most of the experiments on irrigated alfalfa have been conducted in the central or western part of the state, where the soils are somewhat higher in phosphorus content than in the eastern part. However, the sandy soils and the reddish colored soil around the Black Hills are generally low in phosphorus and respond to the use of phosphate fertilizers.

Protein and Phosphorus Content of Hay Increased

Protein content of grass hays is almost without exception increased sharply as a result of nitrogen fertilization. The data in Table 14 are

Table 13. Tons of Alfalfa Hay Produced per Acre When Various Amounts of Phosphate Fertilizer Were Applied Under Irrigation

Pounds of	Bennett County	Beadle County		Butte County† Vale	Butte County† Arpen	Spink County	Custer County
P_2O_5 per Acre	1951*	1951	1952*	1952	1952	1950-52‡	1950
	T./A.	T./A.	T./A.	T./A.	T./A.	T./A.	T./A.
0	1.23	3.35	1.80	2.18	4.22	4.77	2.22
20	1.39	—	—	—	—	—	—
40	1.29	3.40	1.76	—	—	—	—
60	0.99	—	—	3.20	4.57	—	—
80	------	3.43	1.89	—	—	4.94	3.58
120	------	—	—	3.34	4.43	—	—

*One cutting only, other data are for seasonal production (two or three cuttings).
†In cooperation with the BPI S and AE.
‡Three-year average yields in a rotation experiment.

examples taken from several typical experiments with different grasses, irrigated and non-irrigated, which illustrate this point.

The use of nitrogen fertilizer in adequate amounts, when moisture is sufficient, has the effect of making the forage a relatively high protein, rather than a low protein, feed. When this fact is combined with that of the increased production obtained, the economics of the use of fertilizer are sharply focused. In one typical example, the extra protein produced by the use of fertilizer on bromegrass was made at a cost of 3.7 cents per pound, compared with the usual cost of 10 to 12 cents per pound for protein bought in common feed supplements. In addition to this consideration, the production of total digestible nutrients per acre is greatly increased.

The phosphorus content of legume hays is also increased by phosphate fertilization. Analyses of several legumes from recent experiments have shown the hay from phosphated plots to be higher in phosphorus content by from 10 to 50 percent of the check or untreated plots. This may be of considerable importance when feeding animals on a maintenance ration of roughages only.

Table 14. Protein Content of Grass Hays Fertilized with Various Rates of Nitrogen at Huron, 1951-52

Grass	Nitrogen Applied, Pounds Per Acre 0	40	80	160
	Protein Content of Hay			
	%	%	%	%
Crested wheatgrass	8.5	9.6	11.6	—
Alta fescue	11.3	12.9	15.7	18.9
Russian wild rye	12.0	15.5	23.1	23.0
Tall wheat	10.8	13.5	15.6	17.8
Ree wheatgrass	9.9	11.3	14.5	17.9
Bromegrass	9.9	9.8	15.3	17.8
Western native grass	7.4	7.8	9.0	—

Seed Production

Growing Legumes for Seed

Alfalfa. Most profit in seed production is realized in growing those varieties of alfalfa that bring the highest prices on the seed market. Only superior adapted northern varieties should be grown for seed in South Dakota. These include Ranger, Cossack, and Ladak at the present time. Some newer varieties, such as Atlantic and Narragansett, may also be grown when registered seed is more generally available. Proper distance must be maintained between fields of different varieties if seed is to be certified.

The practice generally recommended in South Dakota is to utilize the rank growth of the first crop for hay and the second crop for seed. The first crop should be cut at such a time that the flowering period of the seed crop occurs during the hottest, driest period of the season. In eastern South Dakota cutting the first crop at the one-quarter bloom stage has generally resulted in highest seed yields from the second crop. Some growers have followed the practice of pasturing the first crop and allowing the second to set seed. This is particularly advantageous in bromegrass-alfalfa mixtures, since the grass usually goes dormant during July and August. Under the drier conditions, as in central and western South Dakota, the best seed yields are obtained from widely spaced rows.

In eastern South Dakota, where moisture conditions may be more favorable for vegetative growth, too wide a row spacing may be inadvisable. Such was the case in the two years 1946 and 1947 as may be seen in Table 15.

Table 15. Effect of Spacing on Alfalfa Seed Yields at Brookings

Year	Row Spacing in Inches			
	[illegible]	12	24	36
	Lbs./A.	Lbs./A	Lbs./A.	Lbs./A.
1946	316	321	309	263
1947	441	487	458	302
Average	**379**	**404**	**384**	**283**

If close plantings are to be utilized for seed production in the west, the fields should be situated on lowland soils where moisture conditions are apt to be more favorable for seed setting and development.

Phosphorus may frequently be a limiting factor in alfalfa culture in eastern South Dakota. In the west (Bennett County), however, applications of phosphorus, with borax and with minor elements, have not significantly increased seed yield. In one of these tests the alfalfa was in solid stand and irrigated; in the second test the alfalfa was grown in rows.

Seed production under irrigation is very profitable when the water is applied with care. Too much water causes a rank vegetative growth and may result in blossom drop. With insufficient water the plants will be stunted and the flowers may "burn." Kind of soil, height of natural water table, and rate of water loss are factors to be considered with irrigation. Water applications regulated

so as to bring about a continuous slow growth of the plant favor seed setting.

In recent years it has been learned that a number of harmful insects, chiefly *Lygus* species and flea beetles, frequently may be responsible for poor seed yields. These insects, in general, tend to increase the frequency of blasted buds, blossom-drop, and shriveled seed in alfalfa. Research has shown that the activity of pollinating insects may be reduced in alfalfa fields badly infested with *Lygus*. In this state, grasshoppers, crickets, leaf hoppers, flea beetles, and the alfalfa seed chalcid have been the cause of extensive damage to forage and seed crops of alfalfa.

Control of these destructive pests is now within the means of every grower of alfalfa through the application of insecticides such as DDT, chlordane, aldrin, and toxaphene. Trial plots in Brookings County which were dusted to control *Lygus* bugs yielded the data reported in Table 16. For detailed directions on the use of insecticides for controlling harmful insects in alfalfa seed fields, reference should be made to Entomology Pamphlet No. 11 (revised 1951) from South Dakota State College.

Table 16. Effect of DDT Applications on Seed Yields of Alfalfa in Brookings County

Year	No Treatment	2 Lbs. DDT
	Lbs./A.	Lbs./A.
1948	5.0	102
1949 (Field No. 1)	13.0	72
1949 (Field No. 2)	0.1	230

Most alfalfa flowers must be tripped in order to set seed. The mechanical action of wind and rain is of little effect in tripping alfalfa flowers. Various species of wild bees are effective tripping agents. Nectar-collecting honeybees succeed in tripping only an occasional flower visited. Under circumstances where they collect pollen, however, the honeybee may become an effective cross-pollinator. Cross-pollination is essential for high seed yields. Increasing the number of honeybees to supplement the activity of the wild solitary bees is of value in practical seed production. The presence of more attractive blossoms on other species of plants in the vicinity usually means that the concentration of bees in the alfalfa field will be reduced, with consequent lowered production of seed.

The best yields of seed are obtained by harvesting when two-thirds to three-fourths of the pods have turned dark brown to black. By cutting in the early part of the day when the pods are more likely to be damp, loss of seed from shattering can be largely avoided. The crop should be windrowed at once and allowed to cure in place. The best practice to follow is to thresh directly from the windrow using a combine with a pick-up attachment.

Sweet clover. Though biennial sweet clover is potentially capable of high seed yields, the rank growth of the mature plants in the second year makes it difficult to harvest and thus to realize this high potential seed yield. In South Dakota, clipping or moderate grazing early in

the season to reduce the rank nature of the top growth may be practiced. The seed yield potential will be reduced somewhat but this is offset by the greater ease of harvesting.

As with alfalfa, adequate soil moisture or irrigation water is essential for high yields of seed. Seeding in widely spaced, cleanly cultivated rows may be required where drought is of common occurrence.

Common Yellow and Madrid, being early flowering varieties, are more likely to set seed and mature before the mid-summer heat and drought, and therefore may be grown for seed with some assurance of success in the central and western areas. Later maturing varieties should be grown only where moisture conditions are more favorable over the entire growing season.

Since sweet clover is an excellent source of nectar, honeybees are attracted to it and are the most effective pollinators. Hives of tame honeybees located near the seed field will aid in increasing the production of seed.

The sweet clover varieties in use today are characterized by indeterminate flowering and uneven ripening of seed; both dead ripe and green pods occur commonly on the same plant. Harvesting so as to obtain the most seed and prevent shattering of the over-ripe pods is therefore difficult. Greatest production is usually obtained by harvesting when about three-fourths of the pods have turned dark brown to black. The crop is usually swathed and then combined from the swath before the stems are completely cured. The grower following this practice accepts the risk of wind damage to the crop in the swath. The grain binder may also be used, with shields being fitted under the elevator and packer platform to catch shattered seeds.

Birdsfoot trefoil. This legume has a great potential for setting seed; yields up to 700 pounds per acre have been observed in this region. Unfortunately, under ordinary field run conditions, the amount of seed actually saved amounts to roughly one-tenth of this amount. As the seed pods ripen they split open and expel their seeds. With a marked tendency toward uneven ripening the difficulties of realizing the full potential are readily appreciated.

Seed should be made on the first crop as there may not be enough aftermath growth for setting seed. If the stand is grazed or clipped, a proportional reduction in seed yield will result.

Seed pods turn golden brown to dark brown at maturity, but due to somewhat indeterminate flowering habits, rather uneven ripening often results. The leaves and stems remain green even though the pods are mature. Under these circumstances, straight combining of the seed crop is not feasible. Any system of windrowing or of binding or bunching promotes seed shattering.

One method coming into use now, suggested by Professor Hughes of Iowa State College, overcomes these difficulties to a great extent. When the greatest number of pods are nearing maturity, but have not

yet shattered, the standing crop is cut and windrowed immediately. Without waiting for the forage to cure or even to dry down appreciably the crop is put up in round loosely-made bales. Bales made loosely enough to permit good circulation and left in the field will cure with no spoilage, and more important, will retain the seed that shatters as the pods dry out. At a convenient time, the bales are taken to a stationary thresher or combine, unrolled and threshed. The forage, having retained its leaves and green color, is of good quality and can be stored in stack or barn for feed.

Red clover. As with other legumes, high seed yields in red clover depend on insect pollination and on weather conditions favoring maximum blossom production and pollinator activity. Honeybees can be relied upon to pollinate red clover if an abundance of bees are present (three to five hives per acre), and if competing sources of pollen and nectar, such as other crops and weeds, are eliminated.

The grower may determine the probable worth of a field for seed production by picking representative heads at random from the field and counting the number of seeds per head. With an average of 20 to 30 seeds per head a yield per acre of from 60 to 90 pounds of seed can be expected.

If the season in the first year is favorable, a small crop of seed can be taken by direct combining in the fall of that year. Normally, seed will be produced on the regrowth following early cutting in the second year. Combining from the windrow or swath is the usual practice followed in making red clover seed.

Defoliants in Seed Production

Defoliant sprays are also coming into more general usage in legume seed harvesting. Spraying when the seed is mature but other plant parts are yet green, will kill back the green top growth so that the crop can be combined directly. No permanent damage is sustained by the plant. The effect is much like that of a good killing frost in the fall.

Growing Grass for Seed

The production of grass seed is closely associated with the weather and soil fertility. Grass requires cool temperature and abundant mois-

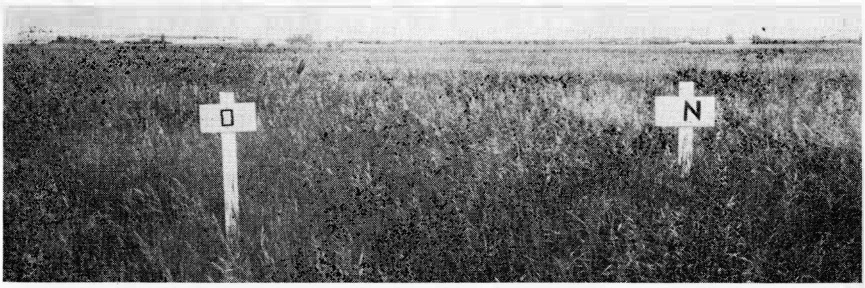


Fig. 6. An adequate supply of nitrogen is needed for grass seed production

Table 17. The Influence of Nitrogen on the Seed Yield of Various Grasses at Different Locations, Irrigated and Non-irrigated

	Crested		Ree	Tall Wheat	Brome			
Pounds of Nitrogen Applied	Beadle County 1951	Beadle County Irrigated 1951	Beadle County Irrigated 1951	Beadle County Irrigated 1951	Beadle County Irrigated 1951	Deuel County 1945	Brookings County Upland 1950	Brookings County Bottomland 1950
	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.
0	25	58	106	148	91	255	243	166
20	—	—	—	—	—	298	—	—
30	—	—	—	—	—	—	—	378
40	187	405	242	296	252	418	—	—
50	—	—	—	—	—	—	700	—
60	285	—	—	—	—	—	—	553
80	—	433	326	372	291	—	812	
90	—	—	—	—	—	—	—	577
120	575	—	—	—	—	—	877	751
160	—	503	193	331	204	—	—	—

ture for maximum growth. Wind and warm dry weather are needed at the time of flowering for good pollination and seed set. In general, weather conditions in South Dakota are well suited to the production of grass seed.

Nitrogen needed for seed production. Grass requires an abundant supply of plant food to produce a good seed crop. In South Dakota, nitrogen is the plant food that most frequently limits yield. When there is not enough nitrogen in the soil for the plants they become pale and are stunted. Established stands may soon become unproductive or "sod-bound" because of an insufficient supply of nitrogen.

Nitrogen can be supplied to the grass either by growing a legume with the grass or by adding nitrogen fertilizer. Growing a legume with a grass that is to be harvested for seed may interfere with harvesting. Grasses seeded in rows and cultivated do not become sod-bound as soon as solid stands; thus the seed yields are maintained at a high level for a longer time before nitrogen must be added.

The application of nitrogen fertilizer is an excellent means of supplying this plant food. Experiments conducted at various locations in the state with several grasses show that seed yields are closely related to the supply of available nitrogen. The results of some of these experiments are shown in Table 17 and Fig. 6. As indicated in the table, large increases of seed were obtained, especially with the higher rates of nitrogen applications. The temperature and humidity relationships were more favorable for seed production in 1950 than in 1951, which may account for the wide variation in the maximum yields. Moisture was adequate during both growing seasons for both the irrigated and non-irrigated experiments.

If the yield of grass seed is to be kept high it may be necessary to cultivate the field occasionally. This may be done with a plow, spring

tooth harrow, disc, field cultivator, and possibly other implements. One suggested method is to plow the field every few years, grow a crop of corn and flax, and then return to grass.

Phosphorus for seed production. Phosphorus also is important in seed production. Experiments conducted in 1950 on a soil which was very deficient in available phosphorus show that both nitrogen and

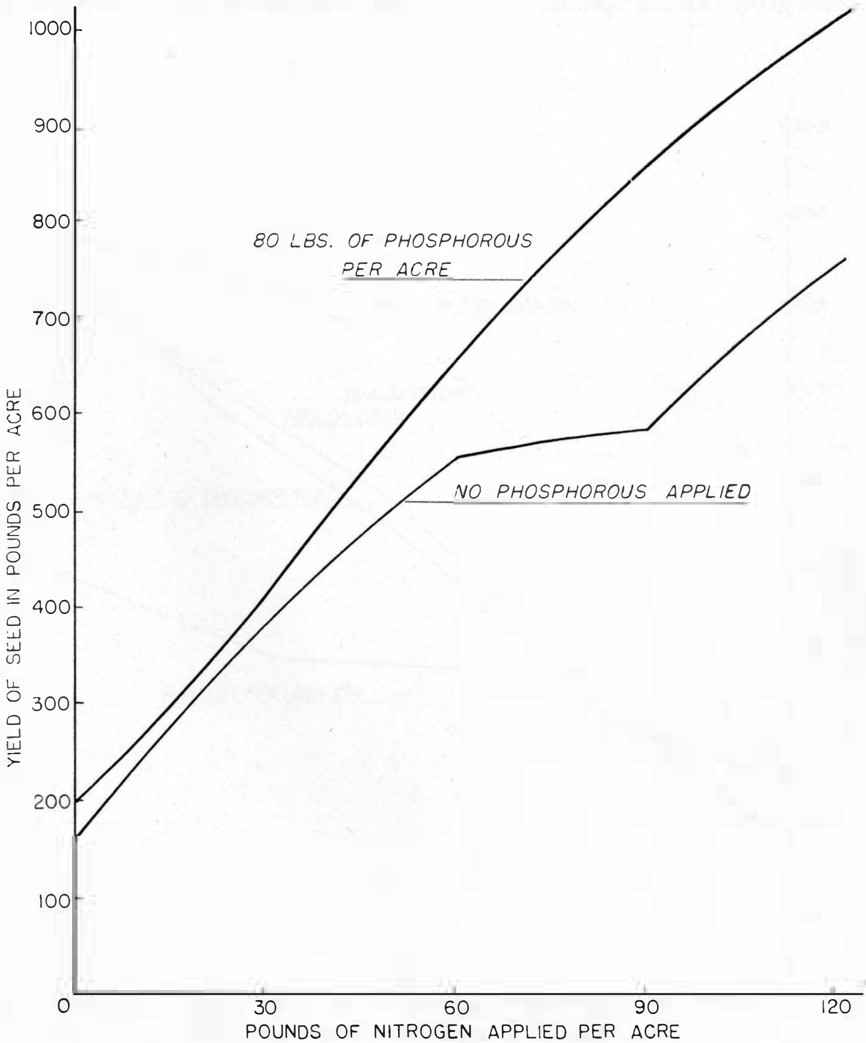


Fig. 7. The effect on seed yields of nitrogen and phosphorus applied in the fall where the available phosphorus in the soil was very low, Brookings

phosphorus are needed to obtain high yields of seed. The results are shown in Fig. 7. This situation is frequently encountered on low, poorly drained areas. Phosphorus seldom increases the seed yield of grass grown on the upland.

Time of fertilization. Nitrogen fertilizer may be applied to grasses either in the fall or early spring. It makes little difference in seed yields whether it is applied in the spring or fall, provided the spring application is early enough. The importance of this is shown in Fig. 8. The grass in

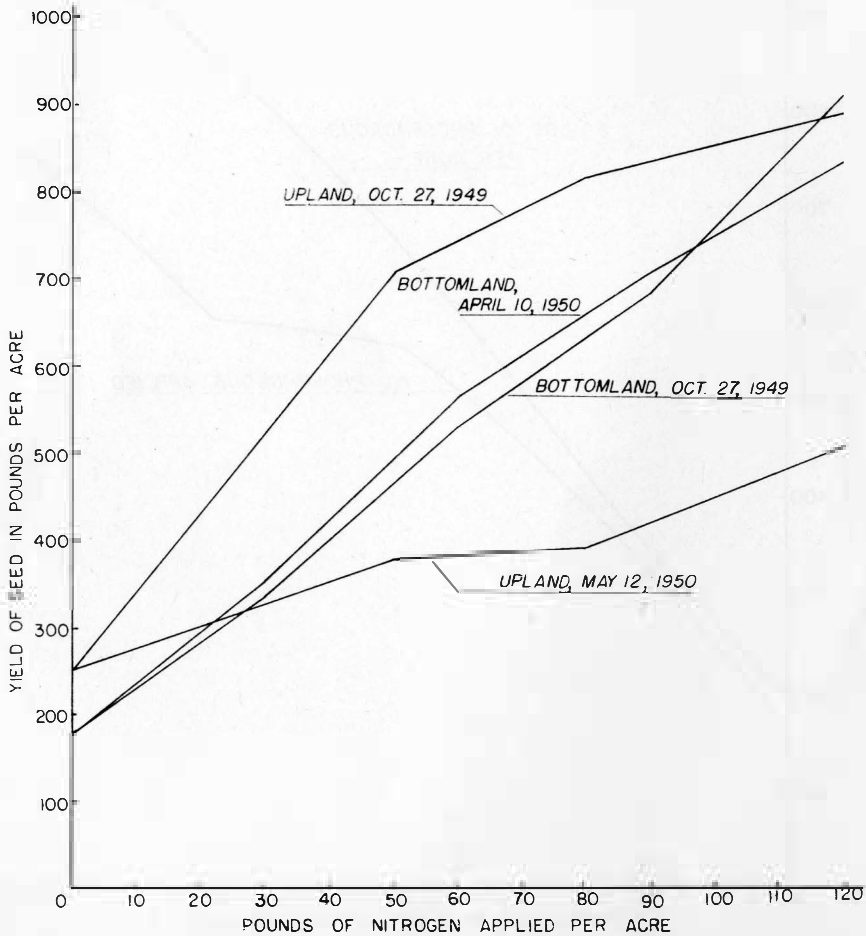


Fig. 8. The effect of time of fertilizer application on the yield of bromegrass seed, Brookings

the two experiments received fertilizer during the fall of 1949 and in the spring of 1950. Note that in the upland experiment the spring application was not made until May 12, which was too late to increase the seed yield very much. The fertilizer, when applied April 10, on the bottom land experiment increased the seed yield approximately the same as that applied in the fall.

Harvesting seed. The most convenient method of harvesting grass seed is to straight combine (Fig. 9). Some of the grasses, such as Ree wheatgrass, Reed canary and others, lose their seeds quite easily and must be harvested just as soon as they are ripe or a little on the green side.

Grasses can be stripped, as with Kentucky bluegrass, windrowed and combined, or they can be cut with a binder and threshed. If legumes are growing with the grass and are tall enough to make it impossible to clip the heads of the grass without taking green leaves, blossoms and possible stems from the legume, it may be desirable to windrow or bind the crop before threshing because of the danger of the green material causing the grass seed to heat. If the windrower or

Fig. 9. Harvesting bromegrass seed with a combine

binder is used in harvesting, it should be set to cut the crop as high as practicable.

If the moisture content of the seed or the moisture in the foreign material is too high for safe storage, the seed can be piled in thin layers on some dry area such as a granary floor. Moving or re-piling will help dry it. Artificial drying methods may also be used.

The presence of quack grass seed in the grass seed makes it unmarketable. If quack grass is present in the field the crop should be utilized for pasture or hay instead of seed production.

Management for Productive Pastures

A pasture, like any other cultivated crop, needs care and attention if high production is desired. The same good practices used in producing cash crops will pay off when modified to suit the various pastures. Pastures are still a rather new crop and not as much is known about them as about the growing and handling of corn and small grains. There are, however, several guiding principles of pasture management that, when used, will help to make a successful and profitable pasture program. These include:

1. Use of adapted strains, species and mixtures.
2. Utilization of the entire growing season.
3. Adjustment of grazing to type of pasture.
4. Maintenance of a stand, 4 to 8 inches, for yield and survival.
5. Adequate supply of plant food.
6. Pasture mowing.
7. Renovation of run-down pastures.

1. Use of adapted strains, species and mixtures. As reported earlier in this bulletin, strains and species vary greatly in their yielding ability. Kentucky bluegrass, for example, produces excellent early pasture, but its yielding potential is much less than that of bromegrass. For pasture a mixture of grass and legume is best. Yields of grass-legume mixtures are always higher than grass alone and usually more than the legume by itself. For maximum production it is necessary to choose adapted strains of high yielding species and grow these in grass-legume mixtures. Usually one or two adapted grasses with a single adapted legume is as good as, or better than, a shot-gun mixture. The following are reliable mixtures adapted to the various areas of the state to be applied on a per-acre basis (Fig. 10).

Area 1. Black Hills and Eastern Areas

Mixture A

Smooth bromegrass	5 lbs.
Ree wheatgrass	4 lbs.
Alfalfa or sweet clover	4 lbs.

Mixture B[4]

Timothy	3 lbs.
Red clover	4 lbs.
Alsike clover	1 lb.

Area 2. James River Area

Mixture A

Smooth bromegrass	5 lbs.
Ree wheatgrass	4 lbs.
Alfalfa or sweet clover	4 lbs.

Mixture B

Crested wheatgrass	6 lbs.
Alfalfa or sweet clover	4 lbs.

Area 3. Central Area

Mixture A

Ree wheatgrass	6 lbs.
Alfalfa or sweet clover	4 lbs.

Mixture B

Smooth bromegrass	6 lbs.
Alfalfa or sweet clover	4 lbs.

Mixture C

Crested wheatgrass	5 lbs.
Alfalfa or sweetclover	4 lbs.

[4]This mixture may be useful under the more favorable conditions where a short-term rotation is desired.

Area 4. West River Area

Mixture A

Crested wheatgrass	5 lbs.
Alfalfa or sweet clover	4 lbs.

Mixture B

Western wheatgrass	5 lbs.
Crested wheatgrass	3 lbs.
Alfalfa or sweet clover	4 lbs.

One grass may be used instead of two in any of the above mixtures, but the amount of seed should be adjusted. Also, within every area special circumstances may call for a special grass. For example, Reed canary grass is suited to low wet fields. Tall wheatgrass is more tolerant to a high salt content (alkali) in the soil.

2. *Utilization of the entire growing season.* The value of a good pasture is greatly reduced if during a part of the season the grass is insufficient to keep the animals thrifty and growing. There are no pasture plants that grow continually from spring to fall and yet produce forage at a high rate and of good quality. This means, then, that on each farm or ranch there should be more than one kind of pasture (Fig. 11). Rye or winter wheat make excellent early spring or late fall pasture. Sudan grass is one of the best hot weather pastures. A grass-legume mixture and native pastures also are needed on each farm to insure a good supply of palatable and nutritious forage. The following pasture calendar suggests crops that can be used to provide good grazing for livestock during different parts of the season.

3. *Adjustment of grazing to type of pasture.* Different species vary greatly in the amount of leaf area developed within 4 to 6 inches above the ground. There is a proper

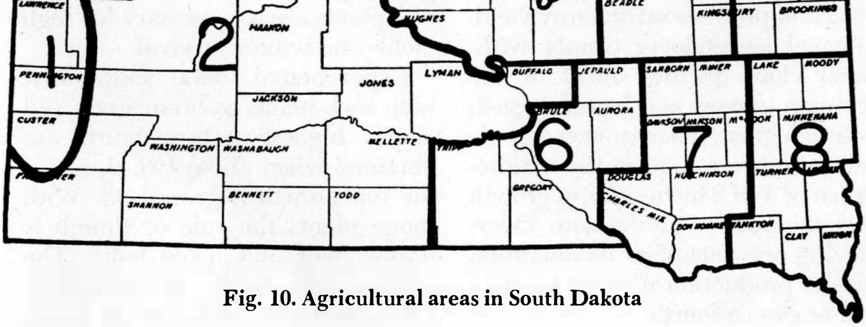


Fig. 10. Agricultural areas in South Dakota

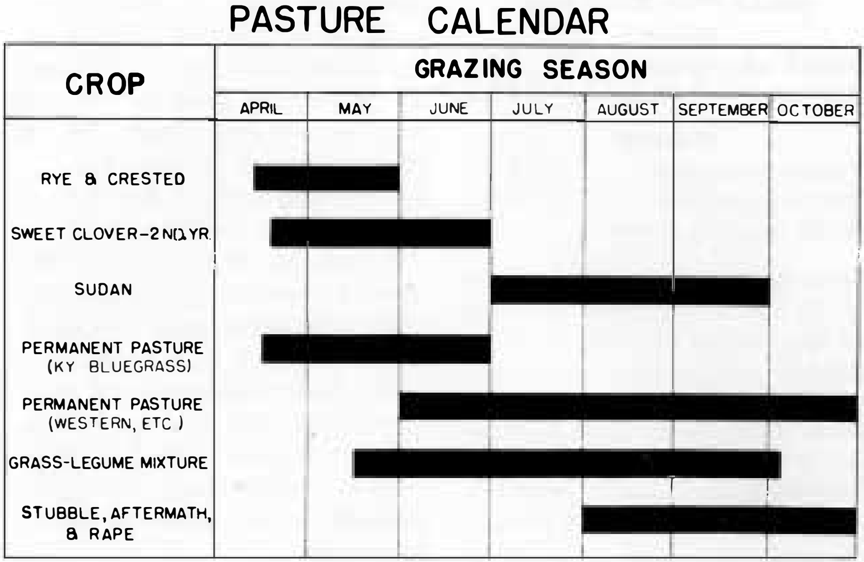


Fig. 11. Suggested crops to provide grazing for livestock from April to October in South Dakota

time and manner for grazing various types of pastures that result in optimum yield and quality. For example, early close grazing is desirable for good quality and high yield on Kentucky bluegrass but is ruinous to alfalfa. Sweet clover and alfalfa have few leaves at the ground level and a 6- to 10-inch top growth must be maintained to insure survival and produce satisfactory yield. Biennial sweetclover cannot withstand close grazing. Most of the common grasses and legumes, such as bromegrass, wheatgrasses, fescue and red clover require the maintenance of 4 to 8 inches of top growth for satisfactory production. Overgrazing prevents plant recuperation so that production is often cut to a half or even a fourth.

4. Maintenance of a stand, 4 to 8 inches, for yield and survival. Considerable green top growth must be maintained since the green portions supply not only additional top growth of the plant but also the root reserves. Repeated and close removal of this green top soon kills the plants. Close grazing also depletes root reserves which in perennial plants are so necessary for high yields and winter survival.

Experimental data show that with such plants as bromegrass and alfalfa, highest pasture returns are obtained when about two-thirds of the top growth is grazed off. With range plants the rule of thumb is "Graze half and leave half." The portion not used by the animals is not wasted but belongs to the plants

and is left to make more and more forage.

New growth is proportional to the amount of green top and to the reserves of plant food stored in the roots. To produce adequate pasture for the entire grazing season and to maintain a high yield and survival, it is necessary to have several types of pastures so the animals can be rotated from one pasture to another. Under most conditions three pastures are the minimum and four are better. The use of a number of pastures rather than only one calls for more fencing and watering places.

5. Adequate supply of plant food. Pasture plants, like other crops, need and remove nitrogen, phosphorus, potassium and other elements from the soil. Depleted soils, especially, need fertilizer to bring them up to normal productivity. Some pastures need phosphorus, and many are starving for nitrogen. Only phosphorus fertilizers need to be added to pastures containing legumes, since legume plants take nitrogen from the air through their nodules. On such pastures about 100 pounds of treble-superphosphate per acre per year is needed to replace the amount removed by grazing and to maintain the soil productivity.

Nitrogen is a serious limiting factor in the production of permanent pastures. This is in part due to a low legume content. On these grass sod pastures an application of 100 to 200 pounds of ammonium nitrate per acre not only will increase greatly the yield and protein content of the forage but will promote earlier growth in the spring. The fertilizers should be applied in the fall or early spring.

6. Pasture mowing. Mowing should be practiced only when there is a reason for it and at the proper time. Generally mowing should be done to: (1) control weeds, (2) prevent herbage from becoming too mature and unpalatable and (3) prevent one plant in a combination from dominating and crowding out another.

7. Renovation and run-down pastures. Many permanent pastures have been neglected and are producing very little feed because of overgrazing, low fertility and weeds. To obtain higher production on these old pastures it is necessary to (1) fertilize the soil, (2) renovate, rework and reseed with higher yielding grass-legume mixtures and (3) control grazing to keep a strong stand of productive pasture plants. Some permanent pastures can be renovated with plowing, but sloping pastures should be thoroughly worked with a disc, springtooth harrow, or field cultivator on the contour to retard erosion and hold moisture. Where there is a fairly good sod, it usually requires from three to four double discings and two harrowings to prepare a satisfactory seedbed. The object is to destroy completely the old sod and leave it on the surface as a mulch. After thorough soil preparation, it should be fertilized, reseeded and managed in accordance with recommendations for good pastures.

Soil Improvement with Grasses and Legumes

The most important soil management problems confronting every farmer are the maintenance of an adequate supply of nitrogen and organic matter in the soil and the protection of the soil from erosion. Legume and grass crops are the only crops which offer a solution of these problems.

Grasses have outstanding value for creating favorable tilth or structure in soils. Grasses make a heavy yearly root growth and since a considerable portion of the root growth dies each year, there is a regular addition of organic matter to the soil. A grass-legume mixture is particularly valuable for soil improvement because nitrogen as well as organic matter is added to the soil.

For maintaining soil fertility the legumes are the most valuable of all crops because they supply the soil with both nitrogen and organic matter (Fig. 12). Nitrogen-fixing bacteria living on the roots of legumes enable these plants to derive a large portion of their nitrogen from the air. The amount of nitrogen added to the soil by alfalfa or clovers depends upon the yield of dry matter and stage of maturity. The earlier stages of growth of legumes, especially sweet clover, are higher in nitrogen, but the yields of dry matter are lower. The analysis of the roots and tops of alfalfa and sweet clover for nitrogen is presented in Table 18.

The data in Table 18 reveal that alfalfa and young sweet clover tops contain about the same amounts of nitrogen. The nitrogen content of sweet clover tops and roots becomes less as the plants get older, but the yield of dry matter per acre becomes larger. It may be assumed that all of the nitrogen in the tops or above-ground parts of the plant came from the air. Therefore, for every ton of hay or dry matter returned to the soil by legumes, approximately 40 to 50 pounds of nitrogen have been taken from the air.

Effect of Legumes in a Rotation on Succeeding Crops

The beneficial effect of alfalfa on the yields of crops may be illustrated by referring to Table 19.

The soil building effect of alfalfa increased the yield of flax 10.2 bushels per acre. The effect of the alfalfa

Table 18. Nitrogen in Tops and Roots of Alfalfa and Sweet Clover

Stage of Growth	Pounds of Nitrogen Per Ton of Dry Matter: Tops	Roots
Alfalfa, 27 inches high beginning to bloom June 17	61.4	46.2
Second year yellow blossom sweet clover 20 inches tall, June 17	57.0	31.8
Yellow blossom sweet clover 3½ to 4 feet tall, seeds beginning to form, July 13	41.6	16.2

Table 19. Effect of Two Years of Alfalfa on Flax Yield, Brookings County 1952

Treatment	Yield in Bu./A.
No legume-corn-small grain rotation	17.9
Alfalfa rotation	28.1

Table 20. Effect of Sweet Clover Rotation on Crop Yields 1947-52

	Yield in Bu./A. Corn	Wheat
Sweet Clover plowed June 15	49.1	26.4
Sweet Clover plowed June 15 with phosphorus fertilizer	50.3	29.2
Sweet Clover plowed August 1	52.6	28.2
Sweet Clover plowed August 1 with phosphate fertilizer	53.3	28.9
No legume corn-oats-wheat rotation	46.0	18.4
Continuous corn or wheat	44.9	19.5

Table 21. Effect of Six Years of Grass on Crop Yields

Rotation	Corn Bu./A. Average 1948 & 1950	Wheat Bu./A. Average 1949 & 1950
6 years brome and 1 year of corn and 1 year of wheat	62.2	24.9
6 years crested wheat grass and 1 year of corn and 1 year of wheat	67.0	24.1
Corn-oats-wheat	60.8	11.8
Continuous corn or wheat	52.6	15.3

Table 22. Changes in Nitrogen and Organic Matter as Influenced by Crop Rotations for the Period 1942-50, Brookings

Crop Rotation	Nitrogen Loss Lbs./A. From Surface Soil	Organic Matter Loss Lbs./A. From Surface Soil
Continuous corn	880	15,136
Continuous wheat	326	4,206
Continuous oats	400	8,620
Corn-oats-wheat	540	8,600
Sweet clover-corn-wheat	300	7,680
Bromegrass 6 years, corn 1 year, wheat 1 year	160	2,940

rotation has not been exhausted by one crop of flax and should last for at least two more years.

The influence of sweet clover on the corn and wheat crop is presented in Table 20. It may be observed from this table that the sweet clover rotations produced substantially higher yields of corn and wheat than the continuous cropping systems of corn or wheat or a rotation of corn-oats-wheat.

The value of grass in a rotation is shown by the data in Table 21. The yields of corn and wheat are higher in the grass rotation than under continuous cropping or in a corn-oats-wheat rotation.

The ability of legumes and grasses to conserve soil nitrogen and organic matter is shown in Table 22.

Fig. 12. Sweet clover plowed under supplies the soil with nitrogen and organic matter. Also, at this time, 100 to 200 pounds of 0-43-0 can be plowed under to restore the phosphorus removed by the crops in a rotation

In the sweet clover-corn-wheat rotation, the nitrogen loss per acre of surface soil was 240 pounds less than for the corn-oats-wheat rotation and 580 pounds less than for continuous corn. In the 6-year bromegrass rotation and one year of corn and one of wheat, only 160 pounds of nitrogen and 2,940 pounds of organic matter were lost from the surface soil. These results show that legumes and grasses not only increase crop yields but also conserve the soil nitrogen and organic matter.

Rotations for Forage Production and Soil Fertility Maintenance

A good legume and grass rotation provides adequate forage and pasture for livestock and is the foundation of a sound soil fertility and soil building program. A sufficient acreage of legumes and grasses should be grown to maintain a balance between soil depleting crops (corn and small grains) and soil conserving crops (legumes and grasses). Under a good soil management program, about one-fourth of the cropland should be used for legumes and grasses. Because of the varied climatic and soil conditions in the state, many kinds of legume and grass rotations are possible. To secure the greatest soil building effects, grasses and legumes should not be allowed to remain on the same field for long periods. In the more humid portions of the state, alfalfa and alfalfa-brome mixtures should be plowed up after they have been in production for three or four years. The following

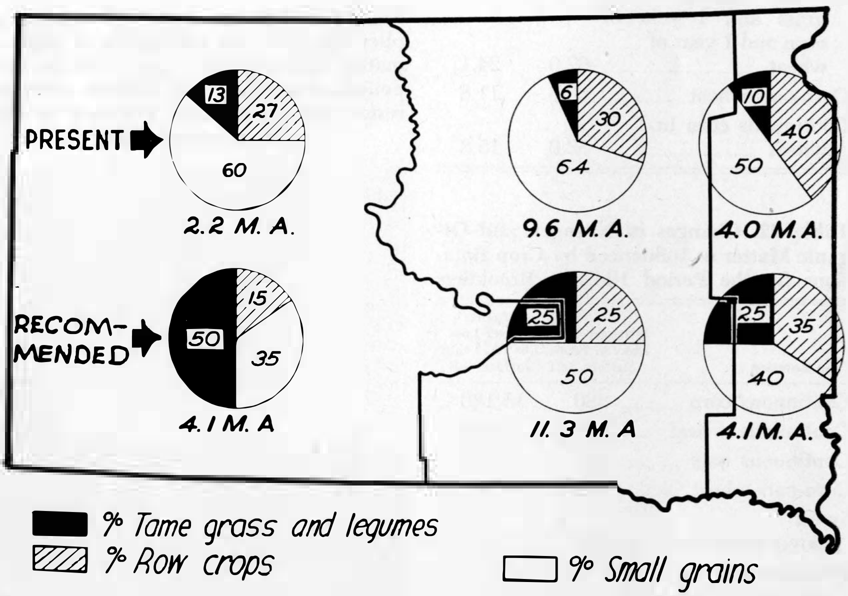


Fig. 13. Use of cropland in South Dakota

rotations are recommended for the various areas of the state:

Small Grain Area

Small grain
Small grain plus sweet clover
Row crop

Small grain
Row crop
Small grain
Alfalfa-brome (2 to 4 years)

Corn
Small grain plus sweet clover
Sweet clover

Range Area

Row crop
Small grain plus clover
Sweet clover-fallow

Small grain
Row crop
Small grain
Alfalfa or alfalfa-grass 4 years

Corn Area

Corn
Small grain plus clover
Clover[5]

Corn
Small grain plus sweet clover
Corn
Small grain
Alfalfa-brome (2 to 4 years)

The percent of cropland in South Dakota which is now in grasses and legumes and the recommended percent of cropland which should be in forage crops are shown in Fig. 13. An increase in the amount of cropland under legume-grass rotations is necessary for the maintenance of soil fertility and conservation of soil resources.

[5]Refers to sweet or red clover for forage, pasture, green manure and seed.

Summary

Some 28,400,000 acres, twice the acreage of all other crops combined, are in grasses and legumes in the state. More efficient production and use of forage crops would insure a more uniform number of livestock, over a series of years, by reducing losses and forced sales of stock because of feed shortage.

Satisfactory stands of forage crops are obtained by seeding in early spring, on a clean firm seedbed and not more than one-half to one-inch deep. The inoculation of legumes, seed treatment on grass seeds and the use of starter fertilizer is recommended.

At present, Ladak alfalfa is the most suitable variety for hay and silage in South Dakota where one and two cuttings are obtained. It is more tolerant to grazing than other standard varieties now available. Where more than two cuttings are normally taken per season, Cossack or Ranger should be grown. Where bacterial wilt is known to occur, Ranger is preferred.

The climate in central and western South Dakota is generally favorable to seed production of alfalfa. Seed of the other major forage legumes adapted here can be grown generally throughout eastern and

central South Dakota. Other factors which must be considered are: control of harmful insects, an abundance of wild or tame bees for pollination, and good management.

The use of phosphate fertilizer on alfalfa is highly profitable on most soils in the eastern and southern parts of the state, as well as on most of the irrigated land in the far west. Soil tests are advised before application of phosphates is made on alfalfa in the central and non-irrigated western areas. Application of four to five surface inches of irrigation water is needed for every ton of hay produced under irrigation.

Locally grown seed of red clover is generally preferred to the named strains. When seed of Dollard is more available, it will be recommended.

For soil improvement, Common Yellow sweet clover is as good as any commercial strain now available. Madrid is a better choice for pasture purposes and seed production and is nearly as good for soil improvement.

Bromegrass, Ree wheatgrass and crested wheatgrass are the most reliable grasses for South Dakota. For pasture and hay a mixture of grass and legume is best.

Maximum hay production requires the use of nitrogen fertilizers on grasses, whether irrigated or not. Nitrogen frequently doubles hay yields and almost always increases the protein content of the forage.

Nitrogen fertilizer should be applied either in the fall or early in the spring. About 40 to 60 pounds of nitrogen (125—190 pounds of 33-0-0) per acre is recommended. In addition to nitrogen, phosphorus may be required on the low, wet, poorly drained soils.

A pasture needs care and attention if high production is desired. To obtain higher yields it is necessary to (1) fertilize the soil, (2) renovate and reseed with higher yielding grass-legume mixtures and (3) control grazing to keep a strong stand of productive pasture plants. To provide adequate pasture for the entire grazing season, it is necessary to have at least three types of pastures so the animals can be rotated from one pasture to another.

The use of legumes and grasses in crop rotations is the foundation of a sound soil fertility and soil building program. Legumes and grasses enrich the soil in nitrogen and organic matter, improve the tilth or soil structure and protect the soil from erosion. The yields of corn and small grains will be substantially increased by legume-grass cropping systems.